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Technical Memorandum No. 33-13
Volume 1, Revision 3

DESIGN STUDY REQUIREMENTS FOR A LUNAR SOFT LANDING SPACECRAFT (SURVEYOR) [U]

C65-958

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JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
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I. INTRODUCTION

The early accomplishment of a lunar soft landing would provide the technical and scientific foundation for the more advanced phases of the NASA lunar program. The technology required for this mission in such areas as attitude control, midcourse maneuver, terminal guidance, propulsion, communication, temperature control, and operating lifetime will represent a significant step in these areas. Further, the accomplishment of the scientific missions would provide data of both scientific and technical interest.

As a first step in the achievement of this mission, the Jet Propulsion Laboratory will initiate a number of contracts for the systems design of the soft landing spacecraft, including a proposal for the implementation of the design study through the development and flight operations phases. On the basis of these studies and accompanying proposals, it is planned to select the systems contractor to carry out the development of the lunar soft landing spacecraft. The systems contractor so selected shall be responsible for the design, development, testing, and flight operations of the lunar soft landing spacecraft system within the constraints of the Jet Propulsion Laboratory.

II. PURPOSE OF THE DESIGN STUDY

The following are the purposes of the design study of the soft landing spacecraft:

1. To ascertain the over-all feasibility of the accomplishment of the missions from injection through midcourse correction and terminal maneuver phases to the operation on the lunar surface. This includes:
    a. Detailed examination of the technical problems to be solved.
    b. The solution of such problems with respect to the present and anticipated technical state of the art.
    c. The solution of such problems within the schedule and time scale allotted. For the purposes of the study, the launching dates shall be assumed to be the period 1963-64.
    d. The solution of such problems with reliability adequate to achieve the over-all mission.
2. To examine the spacecraft mission capabilities within the over-all feasibility in terms of:
    a. Scientific instrumentation capacity.
    b. Information rate.
    c. Lifetime.

d. Versatility of the spacecraft for use on missions other than lunar soft landings (i.e., lunar and planetary orbiting) as well as increasing the adaptability of the vehicle to new developments resulting in improved performance. It is suggested (not requested) that the design study consider flexibility in as many of the major subsystems as possible. It should be noted that this flexibility is of secondary interest and should not be considered if it is a serious detriment to the lunar soft landing missions.

3. To generate the preliminary design of the spacecraft.

III. SCOPE OF THE PROPOSAL AND THE STUDY

A. Proposal

In the following pages are outlined the technical constraints and boundary conditions which must be met by the design study for the soft landing spacecraft. These outlined constraints will be further discussed in a document to be presented at the bidders' conference and in another document to be given to the successful contractors at the start of the design studies. Within these constraints, the design study contractors will have complete technical freedom of design to carry out the purpose of the design study.

As a first step in the selection of the design study contractors, the prospective study contractors are asked to submit to the Jet Propulsion Laboratory a proposal for the design study of the soft landing spacecraft. This proposal should outline how the prospective contractors will approach the spacecraft design study problems within the constraints and boundary conditions applied. It should outline what the prospective contractors feel to be the important technical problems, how they will seek the solution to these problems, and what technical compromises will be examined during the study. The proposal should also outline what manpower and facilities will be utilized during the study period. It is very desirable that the prospective contractors indicate what previous and current programs they have participated in which they feel qualify them for the design study of the spacecraft.

B. Study

The design study proper shall consist of two main sections. The first section shall be the preliminary design of the soft landing spacecraft with technical study of the problems as outlined in Section II. The scope of the design study shall be the over-all soft landing spacecraft system, including the design of the appropriate subsystems, ground support equipment, etc. The second section shall consist of a proposal for the implementation of the preliminary design of flight hardware covering the actual design, qualification, fabrication, testing, and field operations.

Although it is intended that the design studies be followed by the aforementioned development contract, it should be pointed out that the design studies are a separate entity and that no commitment to a follow-on development contract is being or has been made.

IV. DESIGN CHARACTERISTICS AND CONSTRAINTS

A. Trajectory and Guidance Analysis

1. Definition of Area of Responsibility and Interfaces

For purposes of the lunar vehicle study, the contractors will be expected to perform the requisite trajectory and guidance analyses. The Jet Propulsion Laboratory is prepared to assist each contractor in this area to the extent of making available certain of the results of its own performance studies to date and the analytical and computing methods used. (See TM 33-13, Vol. 2, Rev. 3 for a detailed description.)

The trajectory analyses required for the lunar vehicle study will be concerned only with the trajectory after injection.[1] Boost phase trajectories will not be part of the study. The Jet Propulsion Laboratory will provide the information required to describe the interface between boost phase performance and coasting performance.

Midcourse and terminal maneuver operations of the space vehicle are the responsibility of the contractor. These maneuvers are likely to depend on the orbit information provided by the ground tracking net. Therefore, the contractors must know the kind of data this tracking net can furnish and the constraints imposed on the system thereby. (For pertinent information regarding defined areas of responsibility and interfaces, refer to TM 33-13, Vol. 2, Rev. 3, Section III.)

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[1] Injection refers to the beginning of the coast period following the final boost phase.

2. Supplementary Information

For better understanding of the magnitude of the trajectory analysis problems and of the definition of the two interface areas, injection and orbit determination, the following brief description of the lunar trajectory is presented. This information is intended only as a guide and in no way restricts the study area.

a. The Over-all Trajectory (See TM 33-13, Vol. 2, Section IV.)

Lunar trajectories are characterized by their transit times. Since a probable constraint for the lunar missions will be visibility from Goldstone for tracking and telemetry reception during the terminal maneuver, the transit time[2] is restricted to approximately 42, 66, or 90 hours. Times in excess of 90 hours show little if any performance advantage, and appear to be impractical for several reasons. Times shorter than 42 hours require excessively high injection speeds.

A lunar trajectory may be divided into three parts corresponding to a boost period, a coast period, and a terminal period. During the boost, the vehicle is accelerated to a velocity and position from which it will coast to the Moon. At the end of the boost period the vehicle is separated from its booster rocket and coasts free, acted on only by gravity. Early in the coast period the orbit is determined by means of ground tracking, and any errors in its flight path can be corrected by a midcourse maneuver. The terminal period is characterized by a retro-maneuver which slows down the vehicle to a soft landing on the moon.

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[2] Assuming Cape Canaveral launch.

[redacted]

b. Boost Period

Acceleration to injection is effected by a boost vehicle having a comparatively invariant trajectory. Because of the nature of the boost vehicle itself, the powered flight is constrained to a specified pitch plane trajectory. This plane can be rotated to get different directions of launching. The path within the pitch plane is approximately fixed, except for the length of the coasting interval prior to the final boost stage. Thus, the primary parameters available for homing on a target are the pitch plane azimuth, the coast time prior to final stage ignition, and the final stage burning time. Of course, the instant of launch can also be varied.

The boost vehicle for the present mission can carry approximately 2500 pounds to injection. This is the separated weight after the last stage of the boost vehicle has been discarded.

Exact coordinates of the injection point depend on the coast trajectory desired and on how the coast trajectory is matched to the boost trajectory. However, the possibilities can be limited to a comparatively small number of permissible trajectories. For example, as already indicated, the transit time is limited to 42, 66, or 90 hours, with the 42-hour case very unlikely. To account for variation of the Moon's position in its orbit in different months, three sample trajectories will suffice. Thus, at most, nine and probably only six basic trajectories need be studied. Typical injection coordinates include:[3]

[3] Refer to TM 33-13, Vol. 2, Section IV for definition of symbols and coordinate systems. This particular set of coordinates is illustrative only.

[redacted]

r	=	6562.8 km	radius from earth center
v	=	10,573.5 meters/sec	velocity relative to earth
V	=	10,970 meters/sec	inertial velocity
ϕ	=	-15.062°	latitude
θ	=	355.470°	longitude
γ	=	1.665°	pitch angle of velocity
σ	=	120.658	azimuth of velocity

In order to implement performance analyses it will be necessary, in addition, to know the accuracy of the injection guidance system. TM 33-13, Vol. 2, Section II contains detailed information.

c. Coast Period and Midcourse Maneuver

The coast period carries the vehicle from injection to the immediate neighborhood of the moon, a distance of about a quarter of a million miles. For all feasible trajectories, the last part of the coast finds the vehicle ahead of and being overtaken by the Moon. This is because these trajectories are all comparatively low energy, yielding vehicle speeds lower than the Moon's orbital speed.

Escape velocity from the Moon is of the order of 2500 meters/sec at the lunar surface. This, then, is the approximate limiting value below which the approach speed of a lunar vehicle cannot fall. The longer transit time trajectories (90 hours) yield approach speeds near this value. The appended 66-hour trajectory has a 2675 meters/sec approach speed, the 42-hour trajectory a 3200 meters/sec approach speed.

Uncertainty in approach conditions due to injection guidance uncertainties are quite large, as indicated in TM 33-13, Vol. 2, Section II. The world tracking net has the capability of determining the true orbit to a high degree of accuracy. This facility will be available as required for providing orbit information to be used in adjusting the lunar vehicle coasting orbit.

If the world tracking net information is used to determine the components of a midcourse maneuver for correcting errors due to injection guidance, it is estimated that the lunar miss components can be reduced to:[4]

Position	± 60 miles
Angle of descent	± 2 degrees
Approach speed	< 1 ft/second

To effect the corrective maneuver, it may be necessary to alter the vehicle velocity by as much as 100 ft/sec in a prescribed direction. In general, the earlier in the coast orbit the maneuver is made the smaller the required velocity increment. On the other hand, the orbit determination accuracy is poor to start with, improving as the coast path lengthens.

d. The Terminal Period

To effect a soft landing, the approach velocity of about 2500 meters/sec must be reduced to a value low enough to avoid equipment damage. The requirement here is to reduce the speed to acceptable landing speed for any of a variety of possible arrival

[4] For details and better estimates, refer to TM 33-13, Vol. 2,

[redacted]

conditions, depending on the position of the Moon in its orbit. The spread in arrival speed due to change in the moon's position is of the order of 100 meters/sec.

3. Tracking Net and Orbit Determination

During a tracking operation the data (angles, Doppler velocity, and range) are fed directly to the communication and computing center at Jet Propulsion Laboratory, where they are processed to yield orbit information. The delay between injection time and the first good orbit determination depends on the degree of success of the launching and the quality of the data received. Refer to TM 33-13, Vol. 2, Section I for details.

Orbit information is based on the injection coordinates. As soon as a good set of injection coordinates is available, it becomes possible to compute any trajectory quantities available in the trajectory computation program. For example, the coordinates of position and velocity, the viewing angles from any of the tracking stations, the position with respect to Moon and Sun, etc., are all available for any specified time in orbit.

B. Communications and Data Handling

1. General

The design of the spacecraft communications system shall be the responsibility of the study contractors. In general, the communications system shall:

1. Provide tracking and command capability as required for the success of the transit midcourse maneuver and terminal maneuver phases of the trajectory and for scientific measurements. This should include the appropriate telemetry for flight evaluation. Further, the flight evaluation shall be the responsibility of the contractors.

[redacted]

2. Provide a communication link capable of returning the scientific data at the information rates and for the lifetime of the spacecraft as required by the scientific mission during transit and after landing.

3. Be consistent and compatible with the ground stations, tracking facilities, and data handling facilities of the deep space instrumentation facility. The detailed description of the deep space instrumentation facility is contained in Section IV-B-1 immediately following. If any modifications or additions to the ground stations' tracking facilities or data handling seem appropriate, they should be outlined in detail in the study.

2. <u>Planned Capabilities of the Deep Space Tracking Net, 1963-1964</u>

a. Introduction

The information contained herein outlines some JPL flight equipment developments compatible with the Deep Space Instrumentation Facility (DSIF) which may be integrated, if desired, into the spacecraft communication systems studied. Additionally, this material outlines the currently planned communications capability, data handling capability, and operational limits of the DSIF which will be applicable during the 1963-1964 period. Preinjection tracking will be accomplished by the standard AMR range instrumentation.

b. Station Geometry

Three fixed stations, the Mobile Tracking Station, and the interstation communication link, are designated as the Deep Space Instrumentation Facility (DSIF). The fixed stations are spaced at approximately 120° intervals of longitude, and are located at Goldstone, California, U.S.A.; Woomera Range, South Australia; and in the vicinity of Johannesburg, South Africa. The approximate locations are given below in Table 1.

Table 1. Station location

Location	Geodetic Latitude	Longitude	Code
Goldstone	35.389°N	116.848°W	GS
Woomera	31.417°S	136.867°E	W
Johannesburg	25.891°S	27.675°E	SA
Mobile Tracking Station	-	-	MTS

The locus of subvehicle points with 5 degree horizon mask angles is shown in fig. 1. This figure indicates the field of view of each station in the Deep Space Net and the overlapping coverage of these stations.

c. Tracking Net Scheduling

The availability of the DSIF on any one probe experiment is dependent on mission priority and equipment availability. Heavy demands upon the DSIF create network saturation problems solvable only by tight scheduling and limited availability. For example, for lunar probes the DSIF would be available on a twenty-four-hour basis for the first three days and about fifteen hours per day for about three months. These fifteen-hour periods would be distributed amongst the three DS stations to provide the possibility of removing one station from the mission for an entire day. After the three-day period, specific twenty-four-hour tracking would be provided on request.

[redacted]

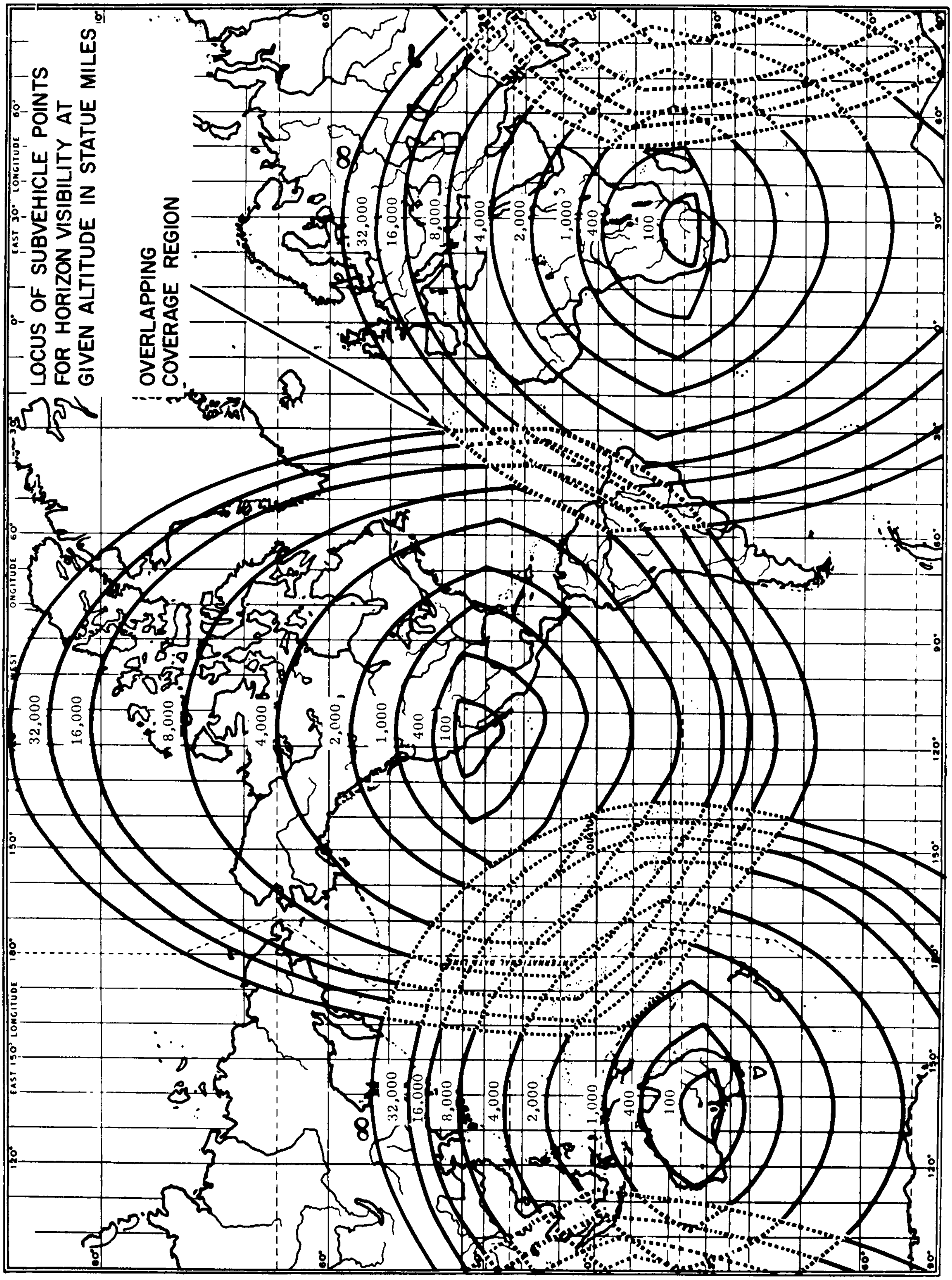


Fig. 1. Station coverage plots for Blaw-Knox polar mounts

[redacted]

After three months, tracking would be furnished only on special request, providing that this tracking would not interfere with any new planned mission, station maintenance, or special experiments.

d. Communications Capabilities

1) Ground Receivers

Table 2 describes the receiver capability of the Deep Space Net.

2) Antenna Temperature Contours

Figure 2 describes the antenna temperature contour of the Goldstone antenna as a function of HA and DEC angles taken at 960 mc/s. The data were obtained using a modified Dicke type radiometer. Temperatures presented are relative to the cold part of the sky which is assumed to be 0°K. The antenna utilized to measure the sky noise had an approximate 1° beam width. Antenna temperatures of the Woomera and the Johannesburg site will be available in 1961.

3) Ground Transmitters

Table 3 describes the transmitter capability of the Deep Space Net. Note that only S-band operation will be available. Initial command capability of three coded audio frequencies will be available in the 1961-1962 period at all three net stations. An information transfer digital command system is currently under development by JPL and will be available in January of 1963 at Goldstone and also at the MTS. Availability at the other net stations is not known at this time. The general system capability is such that binary data can be transmitted continuously at the rate of 1 bit/sec after system lock-on.

Table 2. Receiver capability

Frequency, mc/s	Use	Date available: GS	Date available: W	Date available: SA	Date available: MTS	System noise temperature, °K (estimated)	Antenna gain, db	Beam width, deg	Polarization	IF bandwidth[e], kc (predetection)
960	lunar and deep space	1961	not planned	not planned	not planned	300[c]	44	1	cir	2
960	lunar and deep space	1960	1960	1961	1960	1460	44	1	cir	2
2295[a]	lunar and deep space	Mar 1963	Mar 1963	Mar 1963	Mar 1963[b]	100[b,d]	50[b]	1/2	cir	2

[a] With ±5-mc bandwidth.

[b] The estimated system noise temperature for the MTS installation is approximately 2000°K, and the antenna gain is 31 db.

[c] 300°K system temperature assumes installation of parametric preselectors (exclusive of temperature of Moon).

[d] 100°K system temperature assumes installation of maser preselectors (exclusive of temperature of Moon).

[e] Loop filters are available down to 20-cps noise bandwidth at threshold. Noise bandwidth is a function of signal level. Separate telemetry detection channels will be available to 1 mc/s.

[redacted]

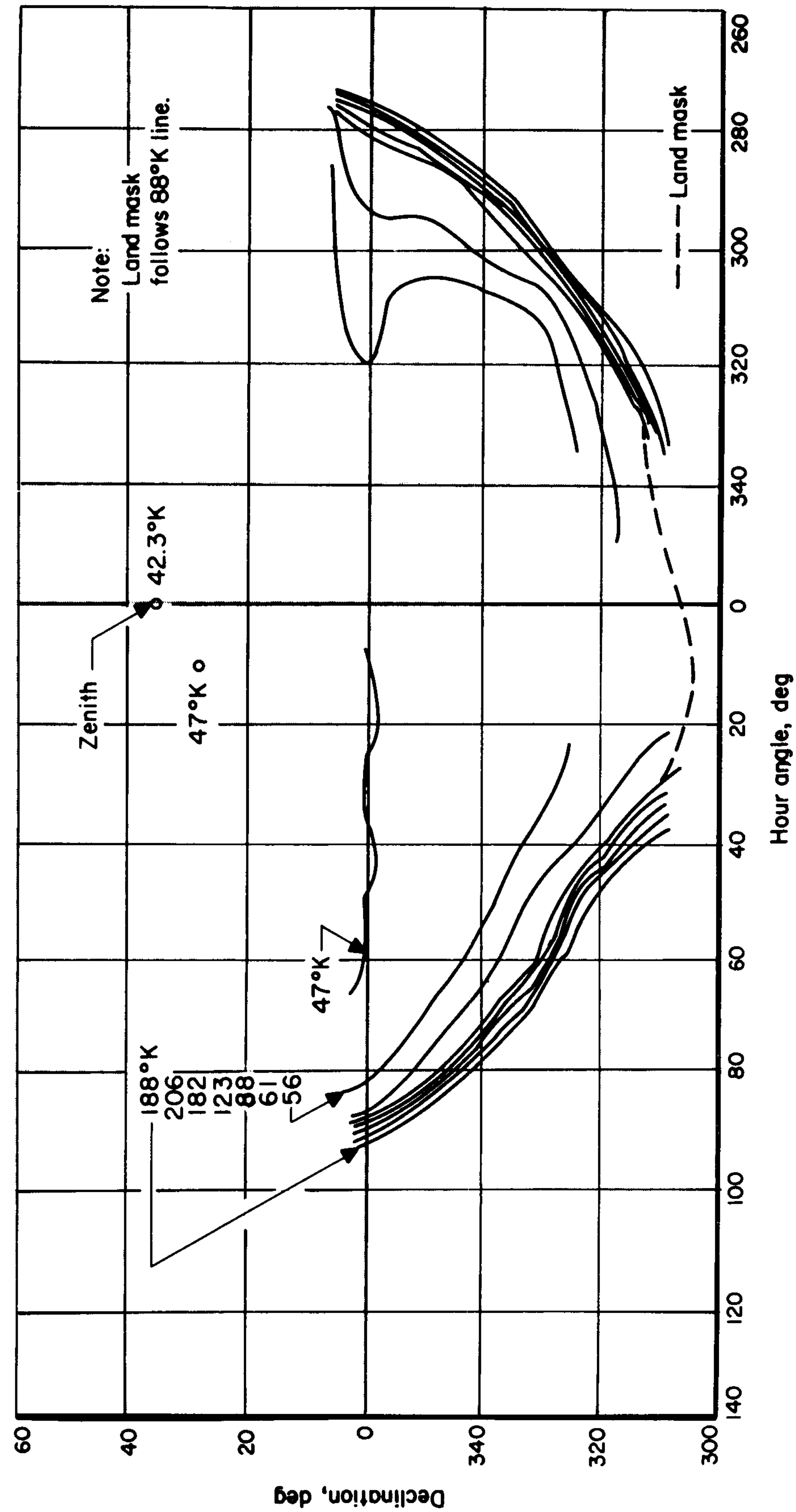


Fig. 2. Goldstone Antenna temperature contour (960 mc)

[redacted]

Table 3. Transmitter capability

Frequency, mc/s	Date available				Antenna gain, db	Polarization	Power output
	GS	W	SA	MTS			
2110-2120[a]	not planned	not planned	not planned	Mar 1963	31	cir	25 w (diplex)
2110-2120[a]	1961	Mar 1963	Mar 1963	not applicable	53[b]	cir	10 kw[b]
2110-2120[a]	Dec 1963	Dec 1965	Dec 1965	not applicable	53	cir	100 kw

[a]This band has not yet been authorized; a request is in process.

[b]The sites at Woomera and South Africa will be diplexed, using a tracking feed. The antenna gain for a diplexed system is approximately 50 db. At the Goldstone transmitting site a searchlight feed is employed, providing an antenna gain of 53 db.

The spectrum of the ground command modulation lies within 100 to 1000 cps. This modulation is composed of wide-band pseudonoise sync information and relatively narrow-band binary modulation of the carrier for binary command data. Present JPL plans are to send command words of a binary length of approximately 17 - 25 bits. This length word would typically contain a start and a stop bit, eleven bits of command information, and four bits for address. With four bits for address, it is possible to have a maximum of sixteen different commands.

It is estimated that the entire spacecraft command system will weigh less than 5 pounds and consume less than 2 watts. Volume will not exceed approximately 150 cu in. These figures do not include the power supply, relays, and storage devices, etc., nor any RF equipment. Acquisition by the spacecraft command decoder may take as much as 10 min after RF transmitter lock-on.

4) System Tracking Data Capability

a) Data Handling

Automatic data handling equipment is presently operational at Goldstone and the Mobile Station; it will be operational at all DSIF stations in 1961. Data format is such that 120 characters can be printed out per line. The system is presently capable of tape-punching 60 characters per second; however, the intersite teletype communication system can transmit a maximum 6 characters per second. The present system transmits doppler data, data condition, station identification, time, and two angles (see Fig. 3). When the ranging capability is added to the DSIF, range will be included in the teletype format (see fig. 4).

b) Angle Tracking

Two maximum tracking rates are available: 1° per sec and 0.03° per sec. At received signal levels from -135 to -145 dbm, and at near sidereal tracking rates, rms tracking error is usually no greater than 0.01° to 0.02°, increasing to 0.04° at receiver threshold. Bias errors are also of this magnitude, but, for the most part, are known; rms errors indicated above are unsmoothed, and tracking data are supplied in near real time (1-10 seconds).

c) Range Tracking

A ranging system is presently under development by JPL which will operate at the S-band frequency shown in Table 3. The system utilizes the phase coincidence of two identical, separately generated, pseudorandom-noise codes, one generated at the transmitter, the other at the receiver. (The pseudonoise spectrum has a bandwidth of ±5 mc.) The spacecraft transponder utilizes the same coincidence technique to reconstruct the code sequence in order to improve the signal-to-noise ratio before retransmission to Earth. Unambiguous presentation of spacecraft range at interplanetary distances is planned with a range resolution equivalent to 0.1 μsec. Since the ranging system is now under development, complete design specifications will not be available until December 1961. For preliminary design purposes it may be

DIGITAL INFORMATION FROM GOLDSTONE RECEIVING ANTENNA

2	Ø	2Ø27Ø5	ØØ144Ø	3281ØØ	1173Ø
2	Ø	2Ø27Ø7	ØØ1316	328228	11732
2	Ø	2Ø27Ø9	ØØØ976	328296	11732
2	Ø	2Ø2711	ØØØ656	328316	11733
2	Ø	2Ø2713	ØØØ332	328364	11733
2	Ø	2Ø2715	ØØØ1Ø4	328416	11732
2	Ø	2Ø2717	359Ø56	32846Ø	11731
2	Ø	2Ø2719	359596	328476	11732
2	Ø	2Ø2721	3595ØØ	3285Ø8	11731
2	Ø	2Ø2723	359272	328536	11731
2	Ø	2Ø2725	359ØØØ	32856Ø	1173Ø
2	Ø	2Ø2727	358756	328632	11732
2	Ø	2Ø2729	358436	328656	11733
2	Ø	2Ø2731	358192	32878Ø	11735
2	Ø	2Ø2733	35804Ø	328876	11736
2	Ø	2Ø2735	35764Ø	328948	11736
2	Ø	2Ø2737	357432	329Ø68	11736
2	Ø	2Ø2739	3571ØØ	32914Ø	11734

DOPPLER FREQUENCY

DECLINATION

HOUR ANGLE

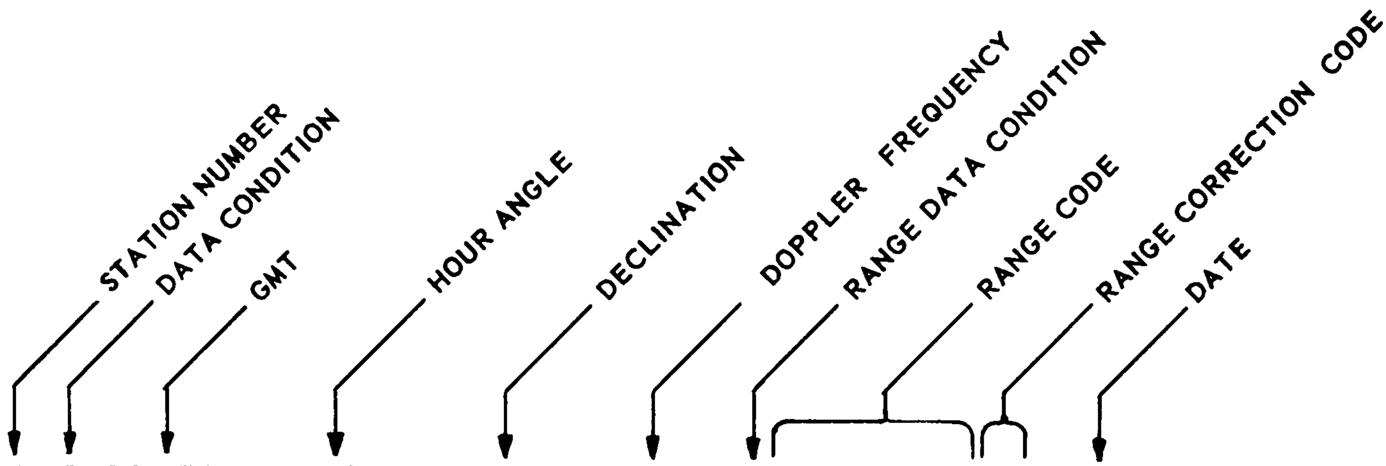
GMT

DATA CONDITION

STATION NUMBER

Fig. 3. Teletype format, present

DIGITAL TRACKING DATA FROM GOLDSTONE STATION

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2 0 014500 359770 345558 11990 100283899018 0301
2 0 014502 359477 345861 11986 100283185819 0301
2 0 014504 359185 346163 11982 100282490518 0301
2 0 014506 358893 346646 11978 100281805720 0301
2 0 014508 358601 346768 11973 100281136219 0301
2 0 014510 358309 347071 11969 100280465022 0301
2 0 014512 358016 347373 11965 000279810320 0301
2 0 014514 357725 347675 11961 000279165021 0301
2 0 014516 357433 347978 11957 000278530922 0301
2 0 014518 357141 348280 11953 000277905319 0301
2 0 014520 356849 348582 11948 000277290821 0301
2 0 014522 356557 348884 11944 000276685722 0301
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Fig. 4. Teletype format, with ranging

assumed that the airborne portion of the ranging system will not exceed 1300 in^3 and 50 pounds, and that the power consumption will be no greater than 100 watts. (Approximately 75 watts are required for a 25-watt Klystron power amplifier.) These figures do not include power supplies, diplexers, and the antenna. The ground-based portion of the ranging system can be utilized to modulate either the 25-watt transmitter or the 10-kw transmitter. All sites, including the Mobile Tracking System, will have ranging capability in March 1963.

d) Doppler Data

A two-way, precision doppler system will be available at S-band by March 1963 at all sites. This system will be capable of an accuracy of 0.2 meters per second for a doppler averaging time of one second, at sampling rates between one sample per second and one sample per 10 seconds at each station except the MTS, where one sample per 2 seconds is maximum. The teletype link is limited to a sample rate of one sample per 10 seconds.

The phase-locked receiver is limited as to its capability of tracking accelerating spacecraft, and this capability is a strong function of received signal level. Figure 5 specifies frequency rate limitations under various signal level conditions.

e) Ground Telemetering

Ground telemetering detection channels provide video bandwidths of 1 mc/sec. These channels will be available at Goldstone by January 1963

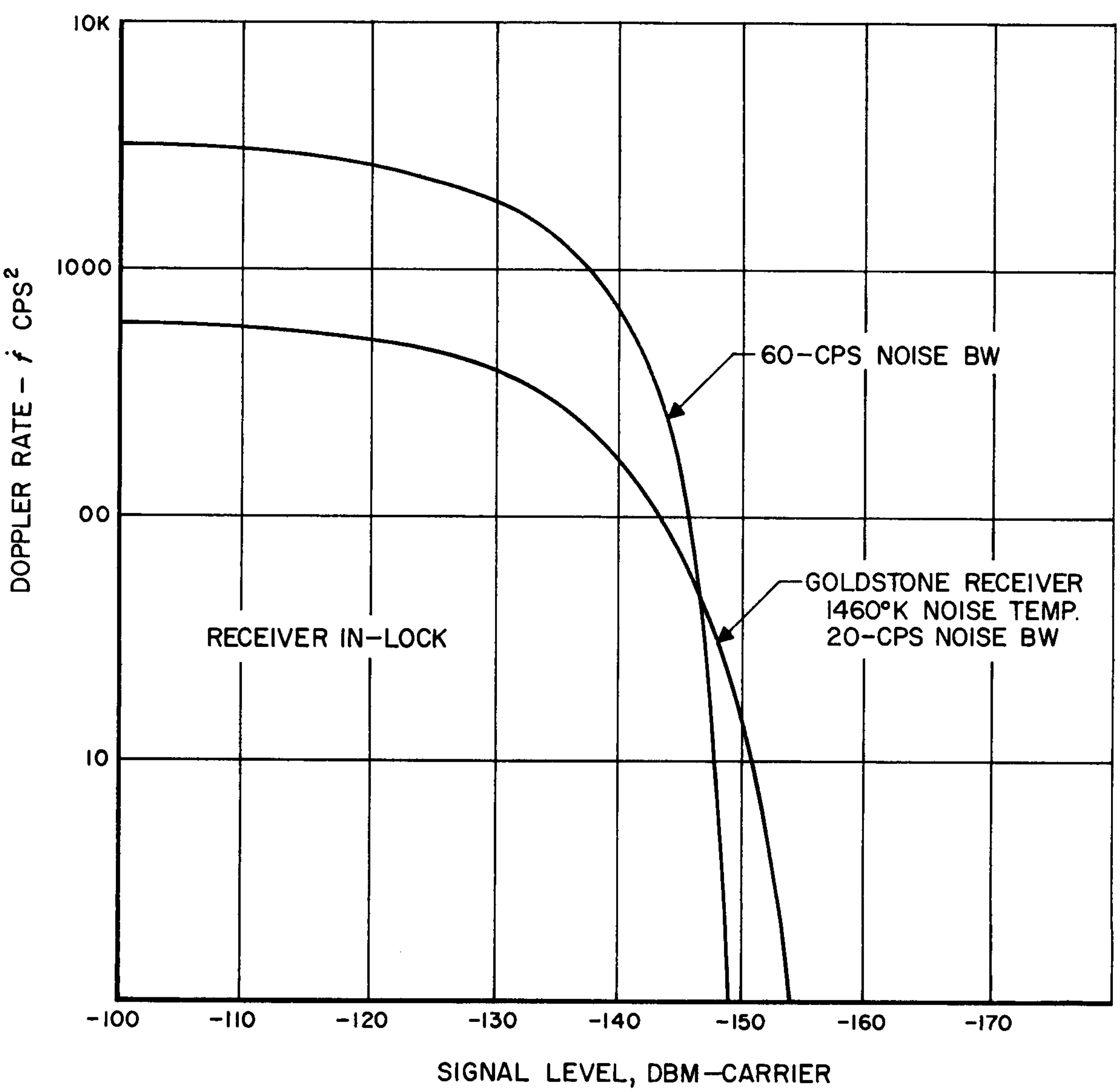

Fig. 5. Frequency rate limitations

and at Woomera and Johannesburg in June 1963. The 1-mc/sec bandwidth will be time-shared with the ranging system. Telemetering information may be frequency multiplexed in this 1-mc/sec bandwidth as requirements dictate. In most instances, the method of subcarrier detection and the logical design of the ground station telemetering system will depend on the particular probe experiment. However, as a standard available capability, IRIG subcarrier detection channels 1 through 7 will be available.

In general, any special purpose equipment at the DSIF shall be limited to modulation, demodulation, and data handling equipment, specifically, for a particular program need. Funding and engineering of this special purpose equipment shall be handled as part of that program and will be a responsibility of the contractor. Facility negotiations and schedules will be the responsibility of the Deep Space Net. Operation of special equipment will be decided by mutual agreement.

f) Acquisition Techniques and Limitations

(1) Ranging system

The difficult task involved in the ranging system is the acquisition of the range code by the spacecraft transponder. (In addition, the transponder must acquire the RF.) The narrow-beam antenna presents pointing difficulties. Ground receiver acquisition is almost immediate once the transponder has acquired the ground transmitter. Two-way acquisition may require periods in excess of 10 min.

(2) Telemetry subcarrier

The telemetry subcarrier is usually dependent on the system used. In general, once the carrier has been acquired, the subcarrier acquisition takes less than 1 min.

g) The communications net linking the three Deep Space Net Stations and the MTS will be those world-wide teletype facilities available to NASA during the time period. The characteristics of this teletype facility are the same as specified in paragraph 4) a), System Tracking Data Capability, Data Handling.

C. Attitude Control and Guidance Systems

For the purpose of this study, the design study contractors shall investigate the requirements, the characteristics, and the design of the attitude control system and guidance system required for the transit trajectory, the midcourse maneuver, and the terminal maneuver phase of the soft landing mission. They shall describe in detail the system finally selected. In cases where new developments are required, every effort should be made to avoid high risk extensions of the state of the art.

D. Physical Constraints and Design Interface

1. Physical Constraints

For the purpose of the proposal, the prospective design study contractors shall consider a spacecraft with the following physical constraints:

a. Injected Weight: approximately 2500 pounds

b. Over-all Shroud Constraints

1) Configuration and Construction

Figures 6 through 9 outline the configuration and construction of the present Centaur vehicle shroud. It would be very desirable from the point of view of spacecraft integration, and of the design of the interface between the spacecraft shroud and the launch vehicle, if this shroud could be retained essentially as shown in the above figures. It is recognized, however, that the shroud volume indicated may be restrictive, and may present an undue constraint upon the lunar soft landing spacecraft design. It shall therefore be one of the purposes of the study to determine the modifications in this basic shroud configuration. The most acceptable modification to this shroud configuration, to gain more working volume, is the adding of cylindrical length at the base of the cone structure. For such modifications, the R-F "transparency" called out for the conical section would not extend to such cylindrical additions.

2) Length

The length of the shroud will be determined by the final spacecraft configuration. In general, except for extreme lengths, there is no length constraint.

3) Diameter

Maximum diameter shall not exceed nine (9) feet.

2. Design Interface

It is most desirable in easing the problem of spacecraft-vehicle integration that the interface between the spacecraft and the vehicle be as simple as possible. The simplest interface is the bolt circle and the single electrical connection required for initiation of the spacecraft

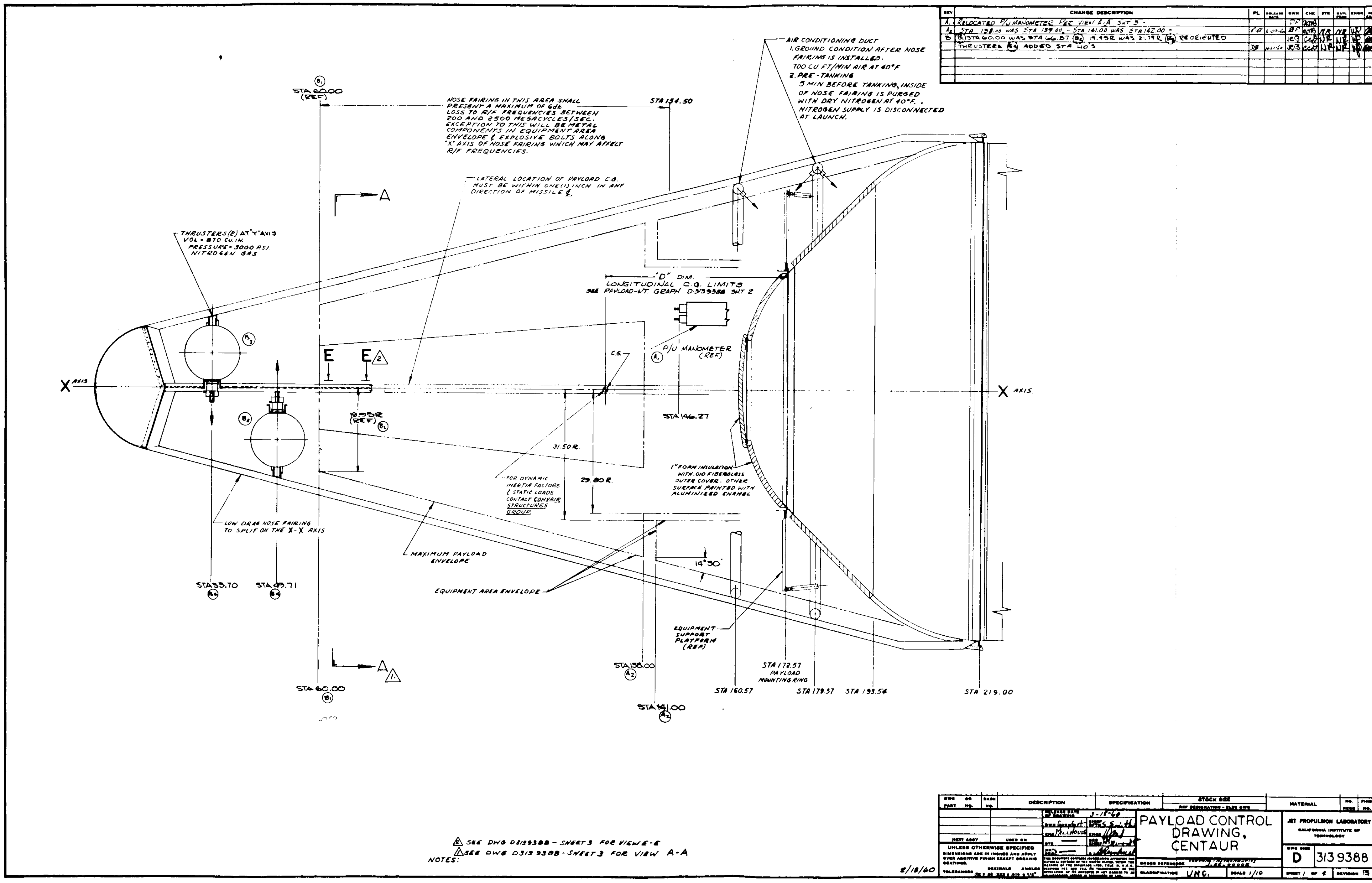

Fig. 6. Payload Control, Centaur

[redacted]

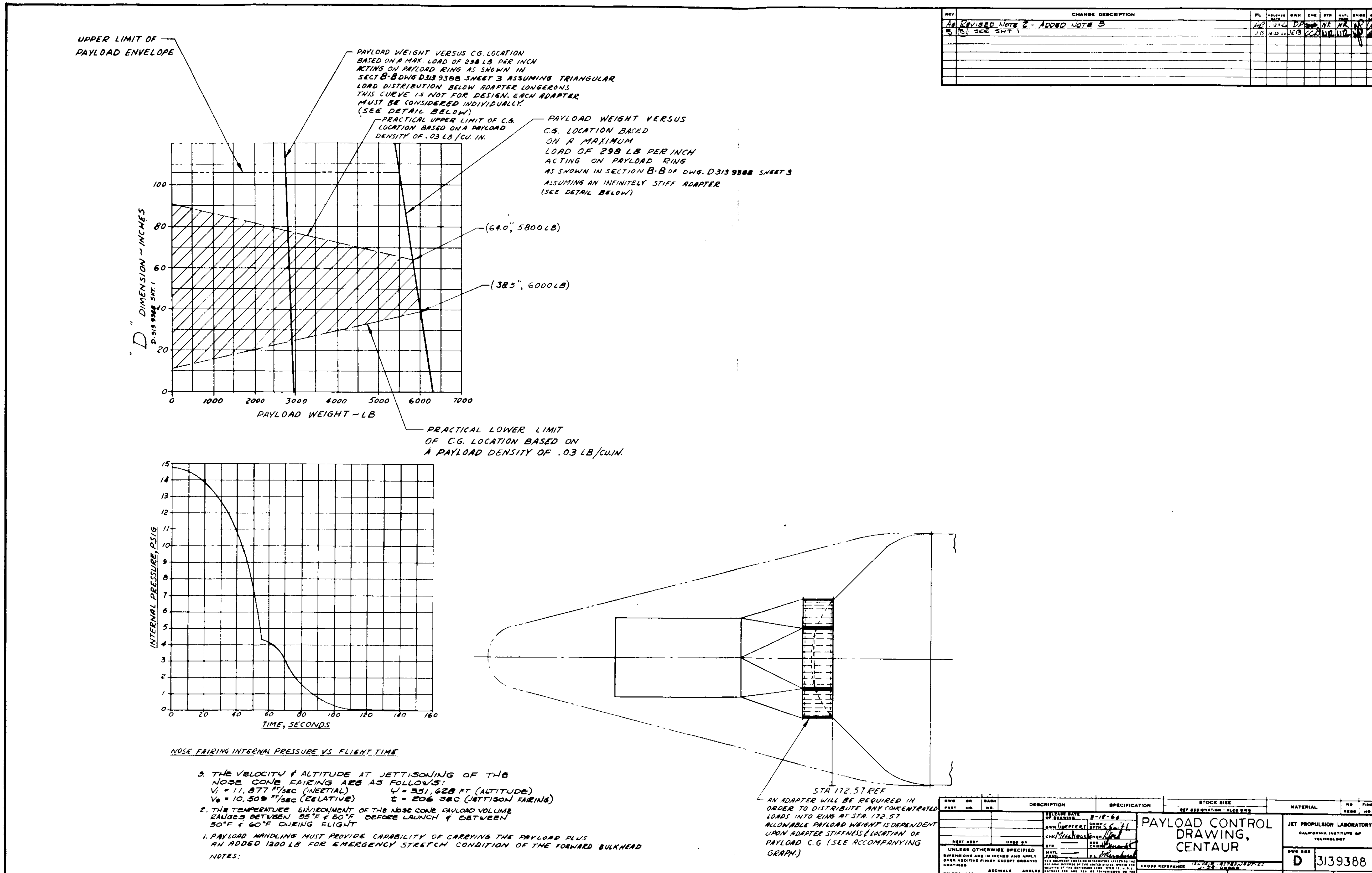

Fig. 7. Payload control, Centaur

[redacted]

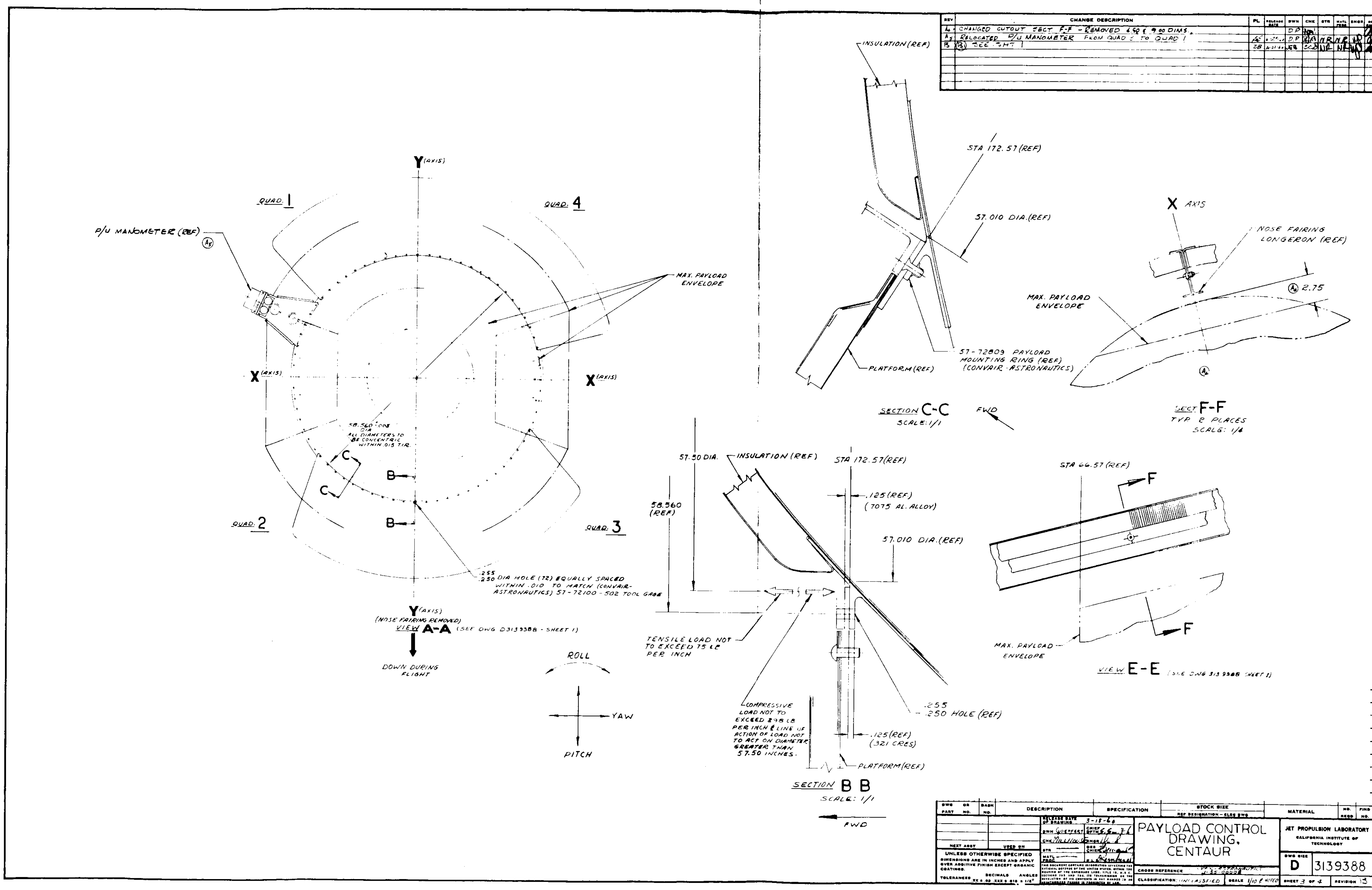

Fig. 8. Payload control, Centaur

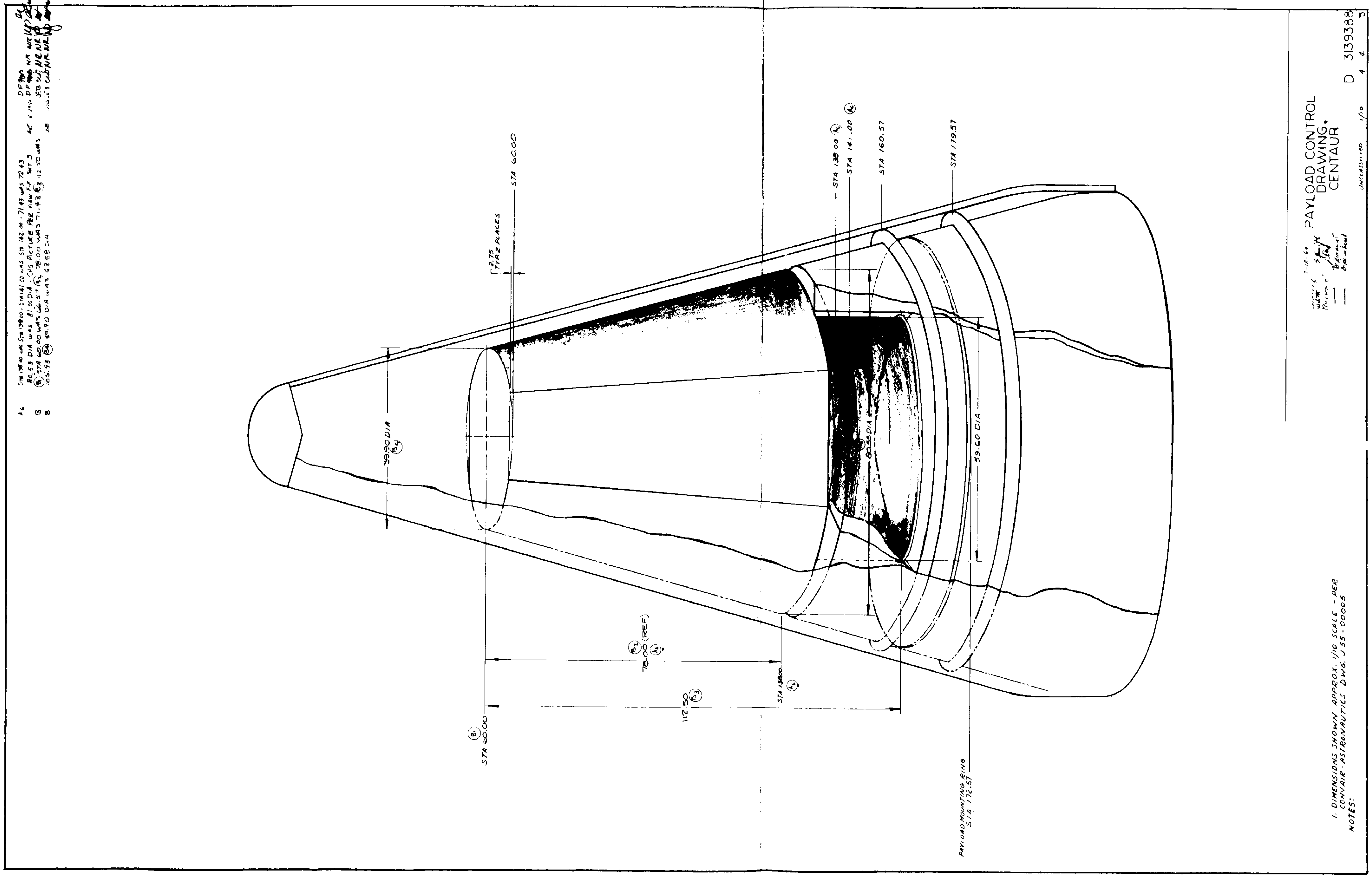

Fig. 9. Payload control, Centaur

sequential operation. It shall be the purpose of the design study to determine any modifications or changes to this philosophy.

3. Spacecraft Adapter and Separation

The design of the adapter section between the booster vehicle and the spacecraft and of the separation device between the booster vehicle and the spacecraft shall be the responsibility of the study contractor. For the purposes of the study, the following criteria shall be followed:

1. The booster vehicle/spacecraft shall be stabilized prior to separation to a maximum rate of 0.1 degrees per second about any axis.
2. Prior to and after separation, the final stage of the booster shall not furnish any additional positive thrust which might cause "banging and bumping" after separation.
3. At separation, the final stage of the booster shall be on a nominal lunar impact trajectory. The requirement that the final stage of the booster shall not impact on the moon will be the responsibility of the booster contractor.

E. Environment

Reference JPL Specification 30213 for the pertinent design information on the environment during launch and burning phases of the trajectory to injection. The remainder of the information included in this specification is for the Ranger spacecraft and shall be disregarded. The environment after injection through lunar operation shall be determined by the design study.

F. Propulsion

The propulsion requirements consist of midcourse corrections or corrections as necessary, and the retro-propulsion to achieve velocity decrements for landing on the moon. The propulsion system is the main power plant plus the controls such as thrust vectoring, reignition, cutoff, etc., where these are necessary.

The following constraints and requirements are imposed:

1. Only chemical propulsion systems are to be considered.
2. Wherever possible, proven design concepts of hardware of established reliability are to be utilized. In cases where new developments are required, every effort shall be made to avoid high risk extension of the state of the art.
3. The development and preflight qualification test program for the propulsion system or systems is to be outlined.
4. Where applicable, the operational sequence and procedures, prelaunch accessibility requirements, and ground service equipment related to the propulsion system or systems are to be described.

G. Sterilization of Lunar Spacecraft

The National Aeronautics and Space Administration (NASA) has established the policy that all spacecraft with trajectories which indicate high probability of lunar or planetary impact shall be biologically sterile to the extent technically feasible. In compliance with this policy, it will be required that the contractor deliver the proposed lunar spacecraft free of viable biological organisms.

Cognizant personnel of the Jet Propulsion Laboratory will be available for consultation on sterilization problems. However, the obligation to provide a sterile spacecraft lies with the contractor. Therefore, the contractor must institute a program that ultimately resolves the problems of the sterilization requirement.

Essentially, the sterilization problem breaks down into two broad categories: internal sterilization and external (or surface) sterilization. Currently it is believed that the most promising methods of internal sterilization are the use of heat (approximately 125°C for an extended period of time) or radiation (10^7 roentgens). A nonflammable mixture containing 12% ethylene oxide gas, and 88% dichlorodifluoromethane, seems to be the most suitable external sterilizing agent.

Spacecraft sterilization can only be accomplished with considerable effort and planning and with close cooperation of the many groups that contribute to its design. In other words, the sterilization problem must be considered and deferred to in the original design concept and in every step of fabrication, assembly, and flight acceptance testing.

The areas of responsibility for sterilization of the Surveyor spacecraft are as follows:

1. The contractor conducting design studies on the Surveyor spacecraft will include in his study methods for achieving sterilization. This study shall include:

    a. Investigations of the feasibility of achieving a sterile spacecraft. These investigations should include tradeoffs between the factors of expense, reliability, and performance.

    b. Estimates of the maximum number of items on the spacecraft which cannot be subjected to sterilization techniques based on a consideration of the schedule requirements and zero degradation of performance and reliability of the finally selected design.

2. Early in the study, JPL will make available to the contractors all data it has related to sterilization and will be available to consult on the problem with the contractors during the remainder of the study period.

3. Although JPL will continue to study aspects of the general problem of spacecraft sterilization and will immediately make available to the contractor new information obtained from these studies, the contractor will not rely on JPL to conduct special research connected with the sterilization of the spacecraft. The contractor will undertake on his own initiative whatever investigations he deems necessary to facilitate his program.

4. During the hardware development period, the contractor will be completely responsible for the development and proper execution of sterilization techniques and procedures.

5. It is expected that close liaison between JPL and the contractor will be maintained during this period. JPL will advise, consult with, and evaluate the methods and procedures recommended by the contractor and will be responsible for the final approval of such procedures and methods.

6. Execution of sterilization procedures will be performed at whatever site is deemed convenient by the contractor, providing the place chosen is consistent with proper sterilization procedures. Actual sterilization of the spacecraft, or parts thereof, will not be conducted by, or at, JPL. However, JPL may perform sterilization tests in-house, to support or verify the validity of methods proposed by the contractor.

7. The provision of equipment and materials required for the testing or actual sterilization of the spacecraft on the premises of the contractor will be his responsibility.

8. The necessary standard or major sterilization facilities required at the launching site will be provided by NASA. Standard or major facilities will be defined as those facilities which are expected to be adaptable for use in sterilizing a variety of spacecraft and may be considered permanent installations.

9. Where special major sterilization facilities (as defined above) are needed by the contractor at the launch site, and existing facilities cannot be modified to meet the required specifications, the contractor will inform JPL of these requirements in his study, and JPL will be responsible for obtaining the support of NASA in providing such facilities.

10. All other sterilization facilities at the launching site, including expendable materials and items, portable apparatus, etc., will be provided by the contractor.

11. The contractor will be responsible for the maintenance of sterility.

12. Status or progress reports on sterilization will be submitted to JPL at regular intervals as a part of the usual engineering reports during both the study period and the development period. Occasional informal reports may also be requested between scheduled reports during the development period. The reports should include:

    a. The kinds of sterilization methods proposed.

    b. A detailed description of the procedure in which the methods are used.

c. Description of tests made in working out sterilization procedures and the results of these tests.

d. Description of development activities relevant to sterilization being carried out in-house or by subcontractors.

e. Additional information which will be required in evaluating the over-all sterilization project proposed by the contractor.

Spacecraft sterilization can only be accomplised with considerable effort and planning, and with close cooperation of the many groups which contribute to its design. In other words, the sterilization problem must be considered and deferred to in the original design concept, and in every step of fabrication, assembly, and flight acceptance tests.

H. Quality Control and Workmanship

For the purposes of the study, the contractors shall prepare a product development schedule which outlines a performance and environmental test plan for each component assembly and for the complete spacecraft assembly.

I. Ground Support Requirements

As indicated in Paragraph 8 on page VIII-3 of TM 33-13, Rev. 2, Vol. 1, "the contractor shall be responsible for analysis, design, fabrication, test, flight preparation, and field operation of the entire spacecraft." Therefore, the study contractor shall include in both the preliminary design and in the proposal for the spacecraft such factors as required to support this responsibility. These discussions should include, but not necessarily be limited to the following items.

1. Determination of appropriate testing and checkout procedures for the spacecraft. These discussions shall include tradeoffs arrived at in the area of reliability.

2. In terms of manpower, equipment spares, etc., the contractor shall be completely responsible for the support of (1) the spacecraft for such functions as subsystem and system testing during fabrication and assembly, (2) prelaunch checkout and preparation, and (3) launch operations. This shall include support both for the blockhouse and launch pad operations.

3. The appropriate spares to support the program. The "spares" philosophy is considered part of the systems responsibility of the contractor and the consideration used to arrive at the philosophy shall be included in the study.

4. The necessary standard facilities at the launching site will be provided by NASA. Standard facilities will be defined as those facilities which are expected to be adaptable for use in support of prelaunch preparations for a variety of spacecraft and may be considered permanent installations. All other facilities such as those at the contractor's plant will be included in the scope of the proposal.

5. Since it is anticipated that the present NASA facilities at AMR for the Ranger program will not be adequate for the Surveyor program, the contractor shall include in the study the determination of the facilities requirement for the proper support of the spacecraft at the launch site. (A suggested format is shown in the following pages.) It shall then be the responsibility of the Jet Propulsion Laboratory to obtain such facilities through NASA.

6. All other equipment at the launching site including expendable materials and items, portable tools and equipment, etc., will be provided by the contractor.

7. In order to give the contractors a better understanding of the AMR and of the booster vehicle operations, a visit for the contractors to AMR is now being arranged.

WORKSHEET FOR FACILITY PLANNING

TYPE OF AREA REQUIRED: Specify whether Test, Office, Assembly, Lab, Special Area, etc.					
1. Number of square feet required (minimum)					
2. Minimum ceiling height	(ft)				
3. Number of personnel using area	-Normal				
	-Casual				
4. Telephone Outlets	-Quantity				
5. Doors for special access	-Width (ft)				
(Specify whether single, double, etc.)	-Height (ft)				
6. Lighting	-Foot candles				
7. Atmospheric Requirements	-Temperature °F				
	-Humidity (max)				
Dust free requirements	-Microns (max)				
8. Electrical Power Requirements	-Voltage				
(For areas requiring more than one type of power, just attach another sheet listing requirements.)	-Phase				
	-Cycles				
	-KVA				
	-Type of Outlet				
	-Spacing				

TYPE OF AREA REQUIRED: Specify whether Test, Office, Assembly, Lab, Special Area, etc.					
9. Work Benches	-Quantity				
	-Width				
	-Length				
10. Storage Cabinets	-Quantity				
	-Width				
	-Length				
	-Height				
11. Hoist or Crane	-Maximum Capacity (Tons)				
	-Hook Height - max.				
	- min.				
12. Special Devices (air, gas, ovens, etc.) Explain use, power, size, etc.					
13. Plumbing (sinks, showers, etc.) Explain type, width, length, etc.					

TYPE OF AREA REQUIRED: Specify whether Test, Office, Assembly, Lab, Special Area, etc.				
14. Ventilation (exhaust or other special type)				
15. Remarks:				

J. Booster/Spacecraft Compatibility Requirements

As indicated in Section IV the spacecraft contractor has the responsibility of determining spacecraft testing and checkout procedures. However, in the area of booster/spacecraft combined testing and checkout, the following requirements shall be met in the development proposal.

1. Mechanical and Dynamic Tests. It shall be assumed that a test firing of the final stage, with a dummy spacecraft installed, will be held in the 4th quarter of 1962. In support of this test, the contractor shall supply a mock spacecraft of appropriate configuration, mass distribution, and rigidities. This test will be held at the Sycamore Canyon facility of Convair. If the spacecraft contractor desires to monitor environment during this test, such monitoring equipment shall be included in their proposal.

2. Compatibility Tests. The contractor shall assume that a test will be made with the spacecraft/final-stage combination for RF and electrical compatibility. The contractor shall supply a mock spacecraft with the appropriate energy sources and radiators to support this test. It shall be assumed that this test will be held at a Convair facility on the West Coast in the 4th quarter of 1962. If the spacecraft contractor desires to monitor performance during this test, such monitoring equipment shall be included in the proposal.

3. The two mockups as required in Paragraphs 1 and 2 shall be flight replicas in the subsystems and systems with which the tests are directly concerned. Whether this requirement is met by a common mockup or flight replica or the individual mockup shall be determined by the contractor.

4. For the purposes of scheduling, the study contractor shall assume a 5-week period of combined booster/spacecraft checkout at AMR prior to launch.

5. Scheduling of transportation and premating checkout of the spacecraft prior to the 5-week period (Paragraph 4) shall be determined by the contractor and be consistent with his own requirements.

6. Any requirements for booster/spacecraft combined testing as required by the spacecraft contractor in addition to the above shall be outlined in his study.

V. SCHEDULE

For the purpose of the proposal the following schedule will be used:

Pre-bidders' technical briefing	13 May 1960
Proposal submission deadline	6 June 1960
Initiation of design study contract	15 July 1960
Design study submission deadline	15 December 1960
Development contract go-ahead	1 April 1961

Flight Schedule: seven (7) flights total, one (1) launching during each of the following months:

April 1963

August 1963

April 1964

August 1964

February 1965

May 1965

August 1965

VI. TECHNICAL REQUIREMENTS OF FIVE-MONTH STUDY

A. Liaison

The contractors shall designate one technical representative within one week following contractual go-ahead. All technical contact, involving technical questions, information, etc., between the Jet Propulsion Laboratory and the contractors shall be channeled through the contractor's technical representative and the Jet Propulsion Laboratory technical representative. Mr. W. J. Downhower is the Jet Propulsion Laboratory technical representative.

B. Technical Reports

1. Informal Status Reports

The contractors shall submit to the Jet Propulsion Laboratory informal status reports (one reproducible and 25 print copies) one week before each of the two technical meetings described in Section VI-C. These reports are to contain a narrative summary of work performed, including technical status, major accomplishments, problems encountered, future plans, etc. The dates of these submissions will accordingly be approximately August 8, 1960 and October 10, 1960.

2. Final Technical Report and Preliminary Design

At the culmination of the study, the contractors shall submit to the Jet Propulsion Laboratory a final technical report and preliminary design. One reproducible and 25 print copies shall be received at the Jet Propulsion Laboratory by December 15, 1960. This report shall contain a factual discussion of the technical findings and evaluations, separated, insofar as possible, into the several technical areas, as well as any other data to facilitate appraisal of the study.

3. Film Documentation

Significant test activities will be documented by the contractors on either 35-mm or 16-mm color motion picture film. Unedited original film or optical printing master accompanied by descriptive camera reports are to be submitted to the Jet Propulsion Laboratory at regular intervals.

C. Technical Meetings

Planned technical meetings between the Jet Propulsion Laboratory and the Surveyor design study contractors will be scheduled for the week of August 15, 1960 and the week of October 17, 1960 for the following purposes:

1. To make available to the contractors the latest information and data affecting the spacecraft design study. Typical of these are:

   a. Initially, the Jet Propulsion Laboratory will provide a broad list of proposed scientific experiments. At the two specified meetings the list of experiments will be defined to delineate more specifically the mission's scientific objectives.

   b. Revisions concerning the number of spacecraft and the launching schedule.

2. The contractors are to give at these meetings a technical status presentation. Because this study is essentially on a competitive basis, the presentation, until the studies are complete, will be considered by the Jet Propulsion Laboratory to be strictly proprietary. This Laboratory will be free to ask clarifying questions

concerning the contractors' presentations, but it is clearly understood that no suggestions or leading questions will be offered by the Jet Propulsion Laboratory.

3. At the conclusion of the design study, the contractors shall make an oral presentation of the design study to the Jet Propulsion Laboratory.

VII. MANAGEMENT ST .UCTURE

A. Introduction

The spacecraft contractors will have major systems responsibility for the designated lunar missions. In order better to understand and define this role and the relation of other organizations to this program, the planned matrix of responsibilities and the statement of primary responsibilities are provided in Table 4.

Table 4. Matrix of responsibilities

	NASA HQ.	JPL	S/C Contr.	MSFC	AF BMD	Veh. Contr.	Test Range
Gross Program Direction	X						
Mission Direction		X					
Mission Development			X				
Trajectory Calculations		0	X	0			
Vehicle				X	0	0	
Vehicle Technical Direction				X			
Vehicle-Spacecraft Liaison		X	0	0			
Spacecraft Preparation			X				
Payload Instrument Coordination	0	X					
Vehicle W/Spacecraft Launch			0	X	0	0	0
Vehicle Tracking				X			0

	NASA HQ.	JPL	S/C Contr.	MSFC	AF BMD	Veh. Contr.	Test Range
Spacecraft Tracking and Raw Data Accumulation		X					0
Vehicle Performance Analysis				X		0	
Spacecraft Data Analysis			X				
Vehicle Report				X			
Spacecraft Report			X				

X: primary responsibility.
0: significant assistance.

B. Primary Responsibilities

1. Program Direction

NASA Headquarters will provide gross program direction, establish the program objectives, and delineate the level of resources available for the program. NASA Headquarters shall also assume the responsibility for intra-NASA and interagency liaison as required.

2. Mission Direction

The Jet Propulsion Laboratory will direct and be responsible for the lunar program, concentrating on the resolution of interface problems brought to its attention. Within the framework of the gross program objectives as established by NASA Headquarters, the Jet Propulsion Laboratory will coordinate, monitor, and execute the lunar program.

3. Mission Development

The spacecraft contractor will plan and implement the designated lunar exploration mission. The contractor will provide a detailed flight schedule and mission plan, develop the spacecraft to implement this mission, specify the vehicle performance requirements, and establish mission objective criteria, and will define and fulfill the requirements for spacecraft-related GSE.

4. Trajectory Calculations

The Jet Propulsion Laboratory will provide the contractor with typical trajectories to indicate the general requirements and restraints. However, the contractor will assume thereafter the responsibility for all trajectory work associated with the spacecraft effort. The Jet Propulsion Laboratory shall perform the liaison functions between the contractor and The Marshall Space Flight Center (MSFC). Interface problems will be resolved by the Jet Propulsion Laboratory.

5. Vehicle

The Marshall Space Flight Center shall be responsible for the procurement of the vehicle, incorporating the unique technical requirements of the particular mission into the vehicle, and for the vehicle's ancillary equipment including the shroud hardware. This procurement shall be to a model specification meeting the mission demands. Included in this procurement responsibility shall be spares, necessary GSE, standard and combined system testing, necessary static firing, shipping, and launching operations including tracking to injection, all in order to meet the requirements of the spacecraft and its mission.

6. Vehicle Technical Direction

The Marshall Space Flight Center shall be technically responsible for all aspects of the launch vehicle system, and will coordinate all GSE requirements for the launching complex.

7. Vehicle-Spacecraft Liaison

The Jet Propulsion Laboratory shall perform the liaison function between the spacecraft and vehicle, aided in this function, of course, by the contractor and Marshall Space Flight Center. Interface problems will be resolved by the Jet Propulsion Laboratory.

8. Spacecraft Preparation

The contractor will be responsible for analysis, design, fabrication, test, flight preparation, and field operation for the entire spacecraft. Sterilization procedures are included in the above responsibility.

9. Payload Instrument Coordination

The Jet Propulsion Laboratory will be responsible for the coordination of payload instruments and experiments.

10. Vehicle W/Spacecraft Launching

The Lunar Mission Director will have over-all responsibility for the mission. Reporting to him will be the Marshall Space Flight Center firing director who has the responsibility for the launching operations. The vehicle contract, ORs, and the spacecraft contractor's operational crews will report to the firing director.

11. Vehicle Tracking

The Marshall Space Flight Center will be responsible for the tracking and data acquisition of the injection vehicle through the injection phase.

12. Spacecraft Tracking and Raw Data Accumulation

The Jet Propulsion Laboratory will be responsible for the tracking, acquisition, and accumulation of data relating to the spacecraft after injection.

13. Vehicle Performance Analysis

The Marshall Space Flight Center will have the responsibility for the accumulation and analysis of the injection vehicle performance data.

14. Spacecraft Data Accumulation and Analysis

The contractor will be responsible for the reduction and analysis of all spacecraft data accumulated in raw form by the Jet Propulsion Laboratory and furnished to the contractor.

15. Vehicle Report

The Marshall Space Flight Center will be responsible for gathering the data, interpreting the results, and preparing and distributing the reports on the injection vehicle and its associated elements.

16. Spacecraft Reports

The contractor will compile the reduced data, interpret the results, prepare the report, and distribute it as directed by the Jet Propulsion Laboratory. Special care will be taken to make certain the basic scientific data is in the hands of the experimenter well in advance of the spacecraft report release. Also, the report will carefully refrain from commenting on the scientific results except for presenting appropriate comments of the official experimenter.

VIII. SUGGESTED CONTENT FOR DEVELOPMENT CONTRACT PROPOSAL

A. Introduction

The contractor shall submit to the Jet Propulsion Laboratory a cost and performance CPFF type proposal for the development, detail design, fabrication, testing, field operations, and data retrieval required to accomplish the lunar soft landing missions as scheduled in Section V. This cost and performance proposal shall contain, as a major element, the contractor's proposed Statement of Work, and the cost portions of the proposal shall parallel elements of this Statement of Work.

The proposal shall consist of three (3) separate and distinct volumes: (1) Management, (2) Cost, and (3) the Study Report as set forth in paragraph B-2 of Section VI. All shall be submitted to this Laboratory in one reproducible and twenty-five (25) print copies, attention F. H. McKibbin, Contract Administrator, and must be received by this Laboratory not later than noon PST on 15 December 1960, and remain firm for at least 120 days from the date of receipt by JPL.

The proposal will be evaluated by JPL. Such evaluation will consider the scientific and technical merits of the proposal, the contractor's background and experience in this and related work and his organization and management, the reasonableness of the cost proposal, and any other factors deemed significant. Those contractors whose proposals are not accepted will be given written notice immediately following the selection of the successful proposal but no explanation of the reasons for selection will be offered. There shall be no communication except as initiated by JPL during the evaluation and review period.

Your attention is invited to the fact that no cost chargeable to the proposed contract can be incurred as an allowable cost before receipt of a fully executed contract or specific written authorization from the Contract Manager of this Laboratory or his designated Contract Administrator.

The contractor agrees not to make, or cause to be made, any public disclosure relative to this proposal without first obtaining written approval of the Jet Propulsion Laboratory for such release by submitting all information for public disclosure to JPL to the attention of the Manager, Contract Administration.

B. Documentation Requirements

The contractor shall at all times maintain and, where appropriate, furnish adequate documentation to describe the flight articles, system support equipment, and other elements developed and fabricated for this project. In addition to the requirements enumerated below, the contractor shall set forth the proposed documentation plan and the method of document change control and shall describe any further documentation requirements that are felt to be appropriate for spacecraft project direction and control, reporting, liaison, and coordination. The documentation plan is to be included in the management proposal (Vol. I), and the associated costs should be reflected in a separate summary in the cost proposal (Vol. II).

1. The contractor shall submit bimonthly engineering status reports in the form of one (1) reproducible and twenty-five (25) print copies. Each such report shall contain a narrative summary of work performed, including technical status, major accomplishments, problems encountered, future plans, etc., and shall include

graphic presentations of actual vs planned labor hour expenditures for both bi-monthly reporting and cumulative reporting.

2. The contractor shall submit monthly Financial Status Reports showing actual vs estimated expenditures plus commitments for the current period cumulative to date, as well as projected expenditures and commitments by month for the ensuing three (3) months.

3. The contractor shall submit a Final Engineering Report in the form of one (1) reproducible and twenty-five (25) print copies.

4. Significant fabrication, assembly, and test activities on the spacecraft will be documented by the contractor on either 35 or 16-mm color motion picture film. Unedited original film or optical printing master accompanied by descriptive camera reports are to be submitted to the Jet Propulsion Laboratory at regular intervals.

C. Management Proposal (Volume I)

The management proposal shall cover at least, but shall not necessarily be limited to, the following, even though certain elements thereof may have been set forth in the Study Report:

1. Provide a Master Project Plan. This plan should include appropriate mileposts in accomplishing all phases of this project and should indicate quantity of end items and their intended use or allocation. A separate schedule of delivery for JPL-supplied instruments for the scientific experiments should be provided.

2. Provide suitable charts, graphs, or other materials which will indicate the manpower necessary for this project (by major division of manpower such as

engineering, fabrication, etc.) and the means for providing this manpower. Reference other projects, present and planned, and present and projected manpower availability.

3. Provide a management plan showing how it is proposed to direct and control all work to be performed, and furnish organizational charts that will clearly indicate the organizational arrangement for this project. Include suggested procedures and methods of liaison, including the coordination and integration of subcontractors, for both management and technical aspects of the work. Management and technical personnel assigned to this project from the intermediate levels and above shall be shown at their respective organizational levels.

4. Provide a resume of experience of all key people who will conduct the technical and managerial affairs involved in this project.

5. Describe how management will ensure reasonable continuity of key management and technical personnel committed to this project throughout the life of the contract.

6. State the priority that management has assigned to this project in relation to other projects. It is anticipated that the National DO-A2 Priority series will apply to any ensuing contract.

7. Furnish a resume of past and present projects by title of effort, contracting agency, and contract number construed to be applicable to the accomplishment of this project. Indicate the management and operational methods used in executing

these efforts, and concisely describe the final and/or predicted performance with respect to original plans, specifications, schedules, and funding estimates.

8. As described in Section B, the documentation plan should be included as a part of the management volume of the proposal.

D. Cost Proposal (Vol. II)

The cost proposal shall include, but shall not be limited to, the items outlined in the following three subsections:

1. Cost Proposal, General

a. The contractor shall submit a standard form DD633 cost and price analysis as a supplement to the requested cost breakdown.

b. A cumulative planned expenditure and commitment rate chart shall be provided in graphic form either as a curve or by step function in time increments not greater than three (3) months each, for the entire life of the planned project.

c. The contractor shall provide a cost summary reflecting documentation plans and requirements as indicated under Section VIII-B.

d. The contractor shall describe the currently utilized, government-owned facilities and equipment that will be required in the execution of this project and shall state what arrangements have or will be made to secure continued use of these facilities and equipment for this project. Also he shall describe what additional government-owned or furnished facilities, equipment, or materials are deemed necessary to the accomplishment of this project, and shall provide: (1) an estimate of the associated costs, and (2) an estimate of the availability of such facilities, equipment, or materials. The contractor shall describe what additional special facilities and/or equipment will be required by this project, and shall state which of these will be acquired at company expense and which will be charged to the project (provide a cost estimate for items in this category).

e. The contractor should recognize that his proposal and the cost elements thereof, while furnished at this time for comparative evaluation of the system and plan as proposed, should be as factual, definitive, and complete as possible. The contractor is hereby advised that this Laboratory recognizes the possibility of certain changes becoming necessary in the contractor's Statement of Work as submitted, as compared with the Statement of Work properly pertinent to an eventual contract. Another cost and performance proposal may be solicited if it becomes apparent that the Statement of Work properly applicable to any eventual contract differs in a significant degree from the Statement of Work as submitted.

2. <u>Cost Proposal, Breakdown</u>

The cost proposal shall set forth each major category of the project paralleling each such category or element set forth in the contractor's Study Report (Vol. III), and, where applicable, categories in Vol. I (such as documentation and project management). Each category shall be portrayed from the cost viewpoint to include operational functions such as development and design, fabrication, test, and field operations. Each function shall include the following elements as applicable:

a. Material Cost

Material as used here means raw materials exclusive of purchased parts to be used in the development and fabrication of the end item or facilities for this project.

b. Subcontracts

Subcontracts as used here includes purchased parts. The contractor shall list potential subcontractors for all major items and shall indicate whether competitive bidding or single source selection is anticipated. Consultants shall also be indicated.

c. Direct Labor

Show estimate of man-months and cost by appropriate employee classification (e.g., Senior Engineer, Engineer, Technician).

d. Travel and Subsistence

e. Packing and Shipping

FOB point destination and proposed method of shipment.

f. Other and Unusual Costs

A separate schedule detailing other or unusual costs applicable to this project shall be attached.

g. Overhead and G&A

h. Fixed Fee

The fixed fee desired shall be set forth as a total dollar amount.

3. Cost Proposal, Supporting Material

Substantiation or enumeration of the costs or factors used in arriving at the estimates given in the detailed cost breakdown in Section VIII-D-2 above shall be provided in the form of separate statements covering the following:

a. Materials

1) Substantiate how costs were computed (e.g., moving averages, acquisition cost, index price, etc.).

2) Substantiate any instances where estimated costs contain elements for material handling or other costs.

b. Subcontracts

1) Indicate the applicable overhead rate, if any, and the basis of its application.

2) If any of the items are to be obtained by intracorporate transactions, describe the method of costing to eliminate "double" profit.

c. Direct Labor

Show the applicable rates for each employee classification. Furnish the following supporting information:

1) What is the present wage or salary rate range for each labor classification?

2) Are the wage or salary rates used in the estimate based on midpoints of effort? If so, what are the midpoints?

3) What is your estimated wage and salary growth rate factor during the period of this effort?

d. Travel and Subsistence. Indicate the method of treating such costs and your established rates and procedures.

e. Royalties

A separate schedule should be attached stating whether the estimated cost of any item includes an amount payable to others for the use of inventions or as fees, etc. For such items the following information should be given:

1) Amount.

2) Basis of calculation.

3) Name and address of party to whom payment will be made.

4) Feature on which paid.

5) Number and dates of patents or applications involved, if any.

f. Independent Research Program

If the recovery of company-sponsored research costs are anticipated as defined in ASPR Section XV (in effect as of the date of contract), set this forth as an item in the total cost estimated. The following questions should be answered in regard to any estimate for this item:

1) What is the basis for the charge estimated in the proposal?

2) Have such amounts been negotiated with any other government agency and for what periods?

3) Do you consider that this project will receive any direct benefit from company-sponsored research effort pursued over the past three years? If so, what is the estimated value of such benefit?

g. Overhead and G&A

Indicate the applicable overhead rate by cost category. Rates quoted shall be designated as "bidding," "negotiated," or "projected," as the case may be.

The estimated overhead and G&A rates shall be substantiated by response to the following:

1) What are the current actual rates in the applicable area?

2) What have the actual rates been for the past three (3) fiscal year periods?

3) If projected rates are used, indicate projected period.

4) Date of your last comprehensive government audit, the period which it covered, and the rates approved by this audit.

h. Fixed Fee

The basis from which the fixed fee is derived shall be defined by the category percentages applied.